LANSCE
Los Alamos Neutron Science Center

Research Proposal for the use of Neutron Science Facilities

☐ Fast Access ☐ Joint CINT Proposal

Proposal Number: 20111561
Submission Number: S1587
Date Received: 03/22/11

Program Advisory Subcommittee: Materials Science
Focus Area:

Flight Path/Instrument: 1FP05-A / ER1
Dates Desired: Early in the run-cycle, possibly 1
Estimated Beam Time (days): 28
Impossible Dates:
Days Recommended: 0

TITLE
Capability development towards energy-dispersive tomography and 3D temperature tomography

☐ Continuation of Proposal #:
☐ Ph.D Thesis for:

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RESEARCH AREA

- ☐ Biological and Life Science
- ☐ Chemistry
- ☐ National Security
- ☐ Earth Sciences
- ☐ Engineering
- ☐ Environmental Sciences
- ☐ Nuc. Physics/chemistry
- ☐ Astrophysics
- ☐ Few Body Physics
- ☒ Fund. Physics
- ☐ Elec. Device Testing
- ☐ Dosimetry/Med/Bio
- ☒ Earth/Space Sciences
- ☒ Materials Properties/Test
- ☐ Other:
- ☐ Mat'l Science (incl Cond Matter)
- ☐ Medical Applications
- ☐ Nuclear Physics
- ☐ Polymers
- ☐ Physics (Excl Condensed Matter)
- ☒ Instrument Development
- ☐ Neutron Physics
- ☐ Fission
- ☐ Reactions
- ☒ Spectroscopy
- ☐ Nuc. Accel. Reactor Eng.
- ☐ Def. Science/Weapons Physics
- ☒ Radiography
- ☐ Threat Reduction/Homeland Sec.
- ☐ Other:

FUNDING AGENCY

- ☐ DOE/BES
- ☐ DOE/OBER
- ☐ DOE/NNSA
- ☐ DOE/NE
- ☐ DOE/SC
- ☒ DOE/Other

DOE/BES

- ☐ DOD
- ☐ NSF
- ☐ Industry
- ☐ NASA
- ☐ NIH
- ☐ Foreign:
- ☐ Other US Gov't:
- ☐ Other:

PUBLICATIONS

Publications:

~25 publications on HIPPO per year

Abstract: S1587_Microsoft_Wo.pdf

By electronic submission, the Principal Investigator certifies that this information is correct to the best of their knowledge.

Safety and Feasibility Review *(to be completed by LANSCE Instrument Scientist/Responsible)*

☐ **No further safety review required** ☐ **To be reviewed by Experiment Safety Committee**

☐ **Approved by Experiment Safety Committee, Date:**

Recommended # of days:	**Change PAC Subcommittee and/or Focus Area to:**	**Change Instrument to:**

Comments for PAC to consider:

Instrument scientist signature: **Date:**

Capability development towards energy-dispersive tomography
and 3D temperature tomography

Scientific Background

Recent developments, based on multi-channel plates, in neutron detector and collimator technology [1,2] allow now to detect neutron transmission with spatial *and* temporal resolution that lends itself to new and unique extensions of classic neutron radiography and tomography:

- Ignoring the temporal resolution, the spatial resolution in combination with commercial software allows tomographic reconstruction of the interior of bulk materials (based on the neutron attenuation).
- Using the temporal resolution, phase-sensitive tomographic reconstruction is possible by means of Bragg-edges [3] belonging to individual phases (based on the attenuation by a specific phase only).
- Using the Bragg-edge positions, the lattice strains for different phases can be probed in 2D and possibly also in 3D.
- Using the Bragg-edge width, the stresses from grain-grain interaction or chemical strains (e.g. carbon concentration in a steel), can be probed in 2D and possibly also in 3D
- Using nuclear resonances in a doped sample, the temperature can be measured in 2D and, as shown in a proof-of-principle experiment by Japanese researchers [4], tomographic reconstruction of a temperature distribution in a sample is also possible.
- The detector is also sensitive to gamma radiation, allowing to explore the unique combination of gamma and thermal neutron radiography/tomography

We established a collaboration in 2011 between Anton Tremsin (UC Berkeley), one of the developers of this detector and collimator technologies, and LANSCE to develop such capabilities here.

Previous work

The abovementioned detector technology has been applied by Dr. Tremsin at all major neutron sources in the world (ISIS, ILL, PSI, SNS, J-PARC) [5], but not yet at LANSCE. This shows that the detector technology is functional. However, LANSCE offers unique opportunities for developing unique technologies:

- The LANSCE initial pulse width of 125 ns allows nuclear resonance spectroscopy. At reactor sources, this technique can only be used only inefficiently via the gamma emission during the resonance absorption. The only other pulsed source in the US, SNS, has a initial pulse width of ~1ms, which is insufficient resolution for epithermal nuclear resonances. This makes LANSCE a unique place in the US for this technique.
- Several specialists for the key techniques of nuclear resonance spectroscopy (V. Yuan) and Bragg-edge transmission (S. Vogel) are present at LANL. In combination with A. Tremsin's in depth knowledge of the relevant detector technology development of unique techniques will be feasible.
- With flightpath 5 a beamline is available that is not heavily oversubscribed and allows development times of a few weeks without interruption.

Proposed Experiments

The present experiments are intended to define a baseline for the ideas outlined above by characterizing the beam characteristics on FP5 with respect to radiographic/tomographic applications, namely beam intensity, beam divergence, and detector sensitivity in the radiation field present in the FP5 cave. Furthermore, we will establish the count times required for temperature measurements via nuclear resonance spectroscopy as well as Bragg-edge transmission measurements. After these basic parameters are established we will acquire several radiographic and ultimately tomographic images. Based on experience with other facilities in the world, exposures of the order of several minutes with 200 projections required are to be expected for tomography. For spatially resolved Bragg-edge and nuclear transmission measurements, also count times of several hours are expected. As sample systems we propose

- A flower in a metal container for the radiography
- The same as above and pipe filled with metal beads for the tomography
- A cantilever for 2D resolved strain measurements.
- A set of foils with isotopes suitable for static nuclear resonance spectroscopy
- The same as above clamped between two steel plates with the top attached to a small heater and the bottom in a reservoir of ice water to establish a temperature gradient for the measurement of a temperature gradient via nuclear resonance spectroscopy and lattice parameter from Bragg-edge transmission. Via several thermocouples spot-welded along the gradient the temperature can be measured conventionally.

In total we expect a beam time of 3 weeks, possibly broken into parts to allow for intermediate hard- and software developments.

References

[1] A.S. Tremsin et al., High resolution neutron radiography with very compact and efficient neutron collimators, Journal of Instrumentation **6** C01041 (2011).

[2] A.S. Tremsin et al., Scatter rejection in quantitative thermal and cold neutron imaging, Nucl. Instr. Meth. A in print (2011).

[3] S. Vogel, PhD Thesis, Kiel University, Germany, (2000).

[4] T. Kamayama et al., Computer tomography thermometry—an application of neutron resonance absorption spectroscopy, Nucl. Instr. Meth. A, **542** 258 (2005).

[5] A.S. Tremsin, presentation given in Lujan Center colloquium February 10 2011 and several publications available upon request.